Developing A Dairy Gaseous Emission Model

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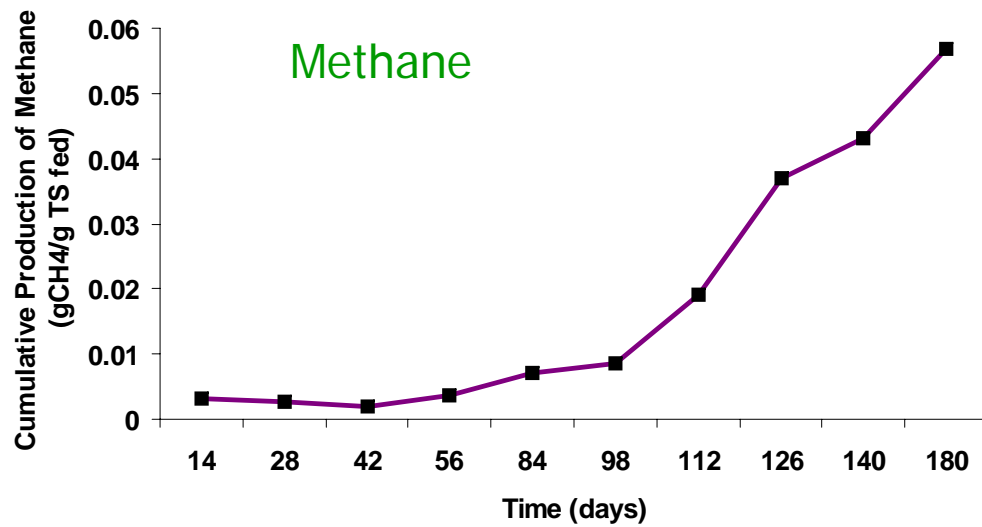# Gases from Manure Sources

Gas emission involves two processes
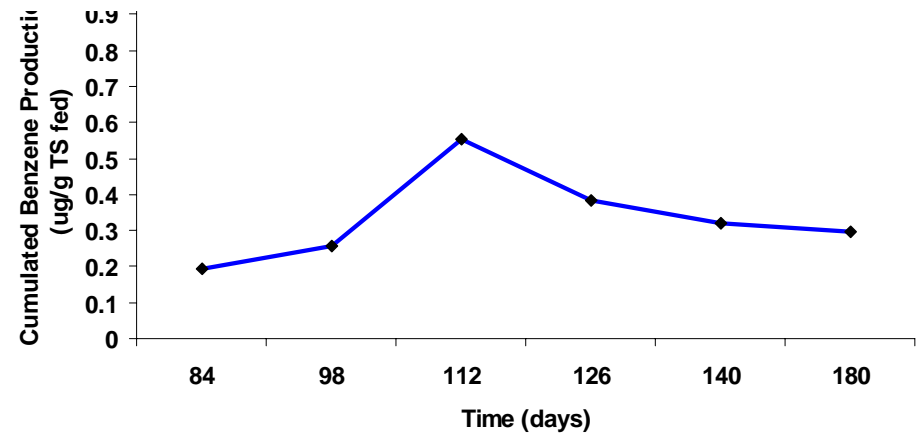 - Generation by biochemical and chemical reactions
 - Mass transfer at the surface

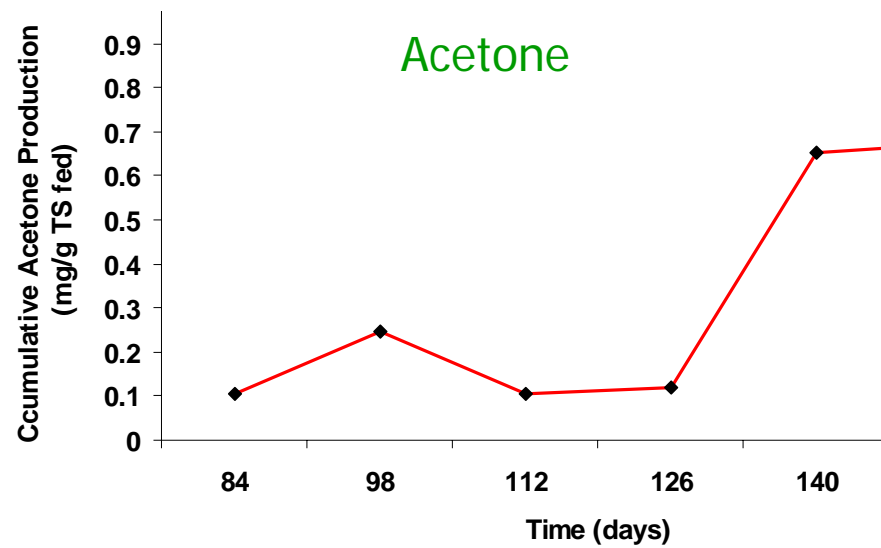Gases
-Volatile organic compounds (VOCs)
-Methane (CH_4), Hydrogen sulfide (H_2S), ammonia (NH_3) and carbon dioxide (CO_2)

Methane

Cumulative Production of Methane (gCH4/g TS fed) vs Time (days)

Acetone

Cumulative Acetone Production (mg/g TS fed) vs Time (days)

Benzene

Cumulated Benzene Production (ug/g TS fed) vs Time (days)

Dairy Emission Model

- Calculate the emission rates of gases (ammonia, VOCs, and hydrogen sulfide) on dairy farms under different animal feeding and manure management practices and environmental conditions.

- Determine key controlling factors for gaseous emissions and design effective emission mitigation techniques.

Dairy Emission Model

Emission Rate

Input

Animal types
and numbers
Feed composition
Housing types
Manure collection
Practices
Manure storage
Conditions
Land application
Weather conditions

Submodels

Feed

C, S, N

Animals

Land
Application

Manure,
Water

C, S, N

Housing

Manure
Storage
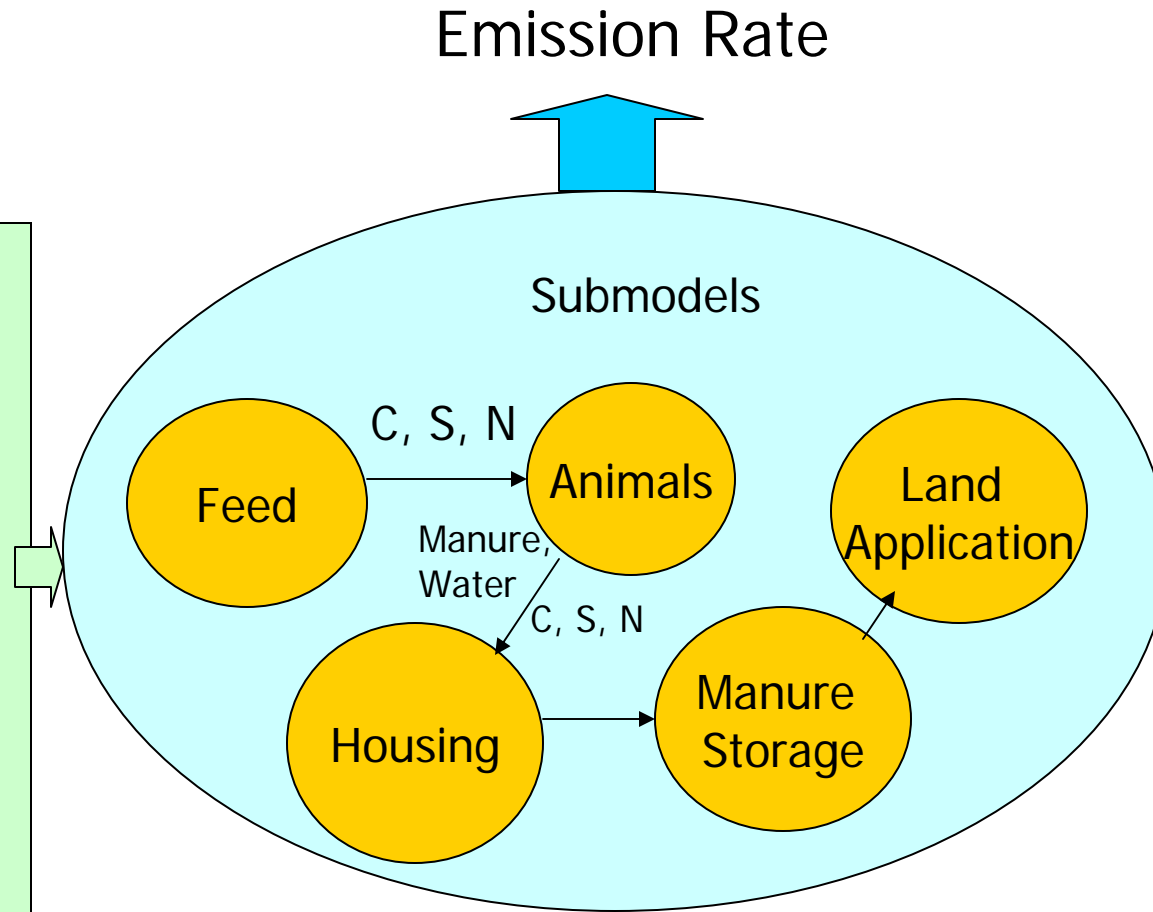
Developing a Process-Based VOC Emission Model (9/06-8/08)

- ## Research Sponsor
  - ### California Air Resource Board

- ## Researchers
  - ### UC Davis – Ruihong Zhang, Frank Mitloehner
  - ### UC Berkley – Allen Goldstein

Research Objectives

- Quantify the generation and emission rates of VOCs, NH_3 and H_2S from silage (fermented animal feed) and manure under different management and environmental conditions.

- Develop a process-based computer model that can predict the emission rates of VOCs from different dairy feed silage and manure storage sources.

Emission Model Validation

- **Controlled conditions**
    - Use environmental chamber and biobubble measurement data
- **Variable farm conditions**
    - Use available farm emission data

Ammonia Emission Modeling Research

- Ammonia Emission Model for Animal Feeding Operations
  - Lake Michigan Air Directors Consortium (LADCo) (2004-2005)
  - USDA National Research Initiative (2006-2008)

Researchers Involved

- **UC Davis**
  - Ruihong Zhang, James Fadel, Tom Rumsey
- **UC Riverside**
  - Zion Wang
- **Iowa State University**
  - Hongwei Xin
- **Virginia Polytech State University**
  - Jactone Arogo
- **Purdue University**
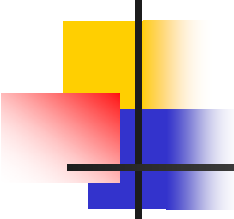 - Albert Heber

Status of Ammonia Emission Model

- Developed but need improvement and validation
  - Animal nitrogen and manure excretion
  - Animal housing
  - Lagoons
  - Land application
- To be developed and validated
  - Feedlot
  - Dry manure storage

Example- Ammonia Emission Model for Manure Storage Lagoon

➢ Calculates ammonia emission rate as a function of

  ➢ Organic nitrogen mineralization rate

  ➢ Ammonia transfer rate from manure into the air

➢ Considers the rain fall and evaporation

Input Parameters for Manure Lagoon Model

- Manure properties
  - pH, ammonia concentration, mineralization rate
- Storage structures
  - Configurations and dimensions
  - Treatment lagoon vs. storage pond
  - Storage period
- Environmental conditions
  - Air temperature, Air velocity
  - Precipitation and evaporation

Effect of Lagoon Configurations and Locations on Ammonia Emission Rate

- Ammonia emission rate from a lagoon holding

  9 million gallons of manure water with 450 mg/L TAN (manure water from 1000 cows for 3 months at 100 gal/cow.day).

  Variables analyzed

  - pH = 7.0, 7.4, 7.8
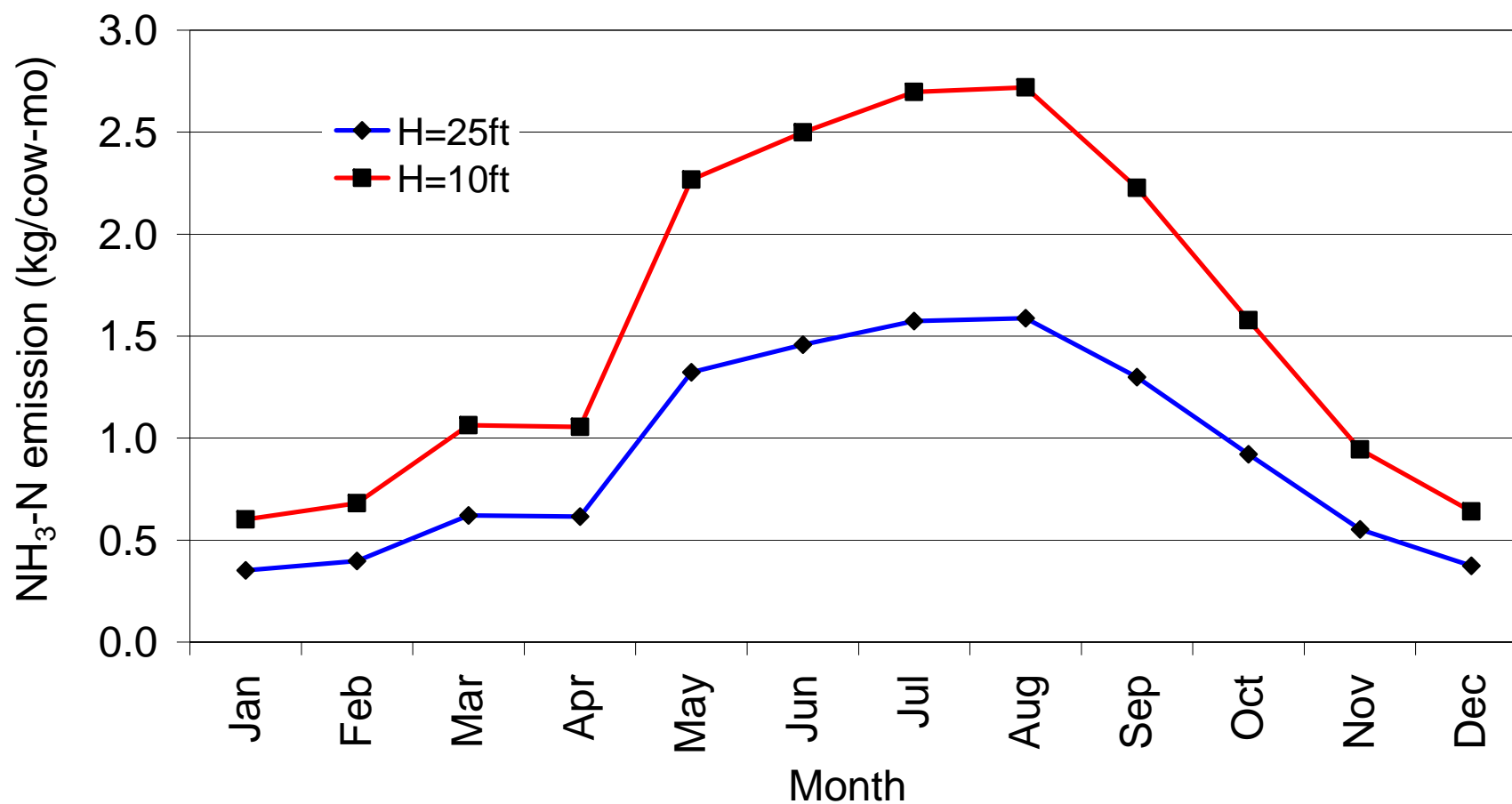 - Depth = 10, 25 ft
  - Locations – Fresno and San Joaquin

Ammonia Emission Rate for the Lagoon in Fresno

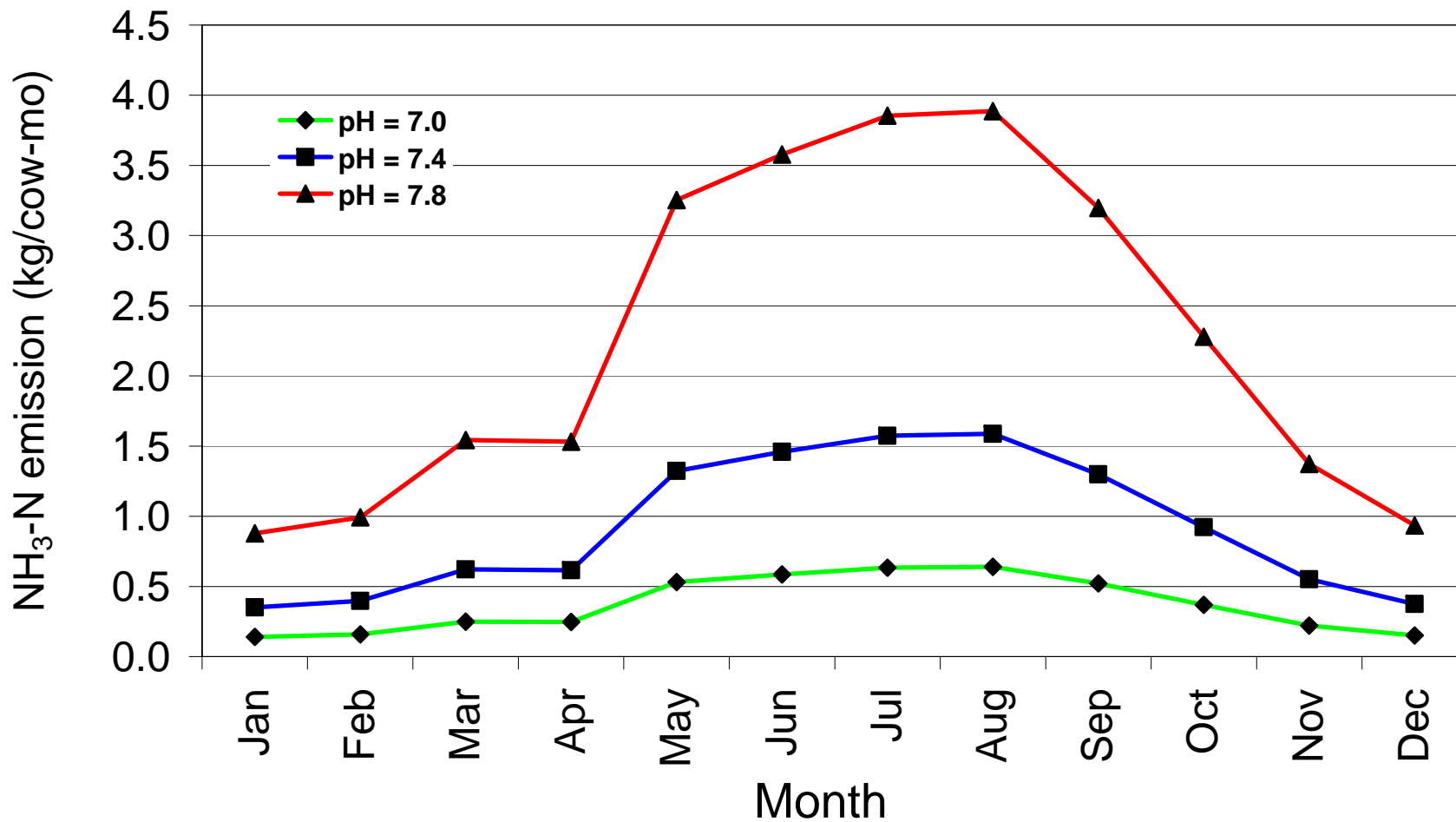| Lagoon Conditions		NH$_3$-N Emission (lb cow^{-1} yr^{-1})
Depth (ft)	pH	
25	7.0	9.7
	7.4	24.4
	7.8	60.1
10	7.0	16.7
	7.4	41.9
	7.8	103.1

N excretion from a cow = 369 lb/year

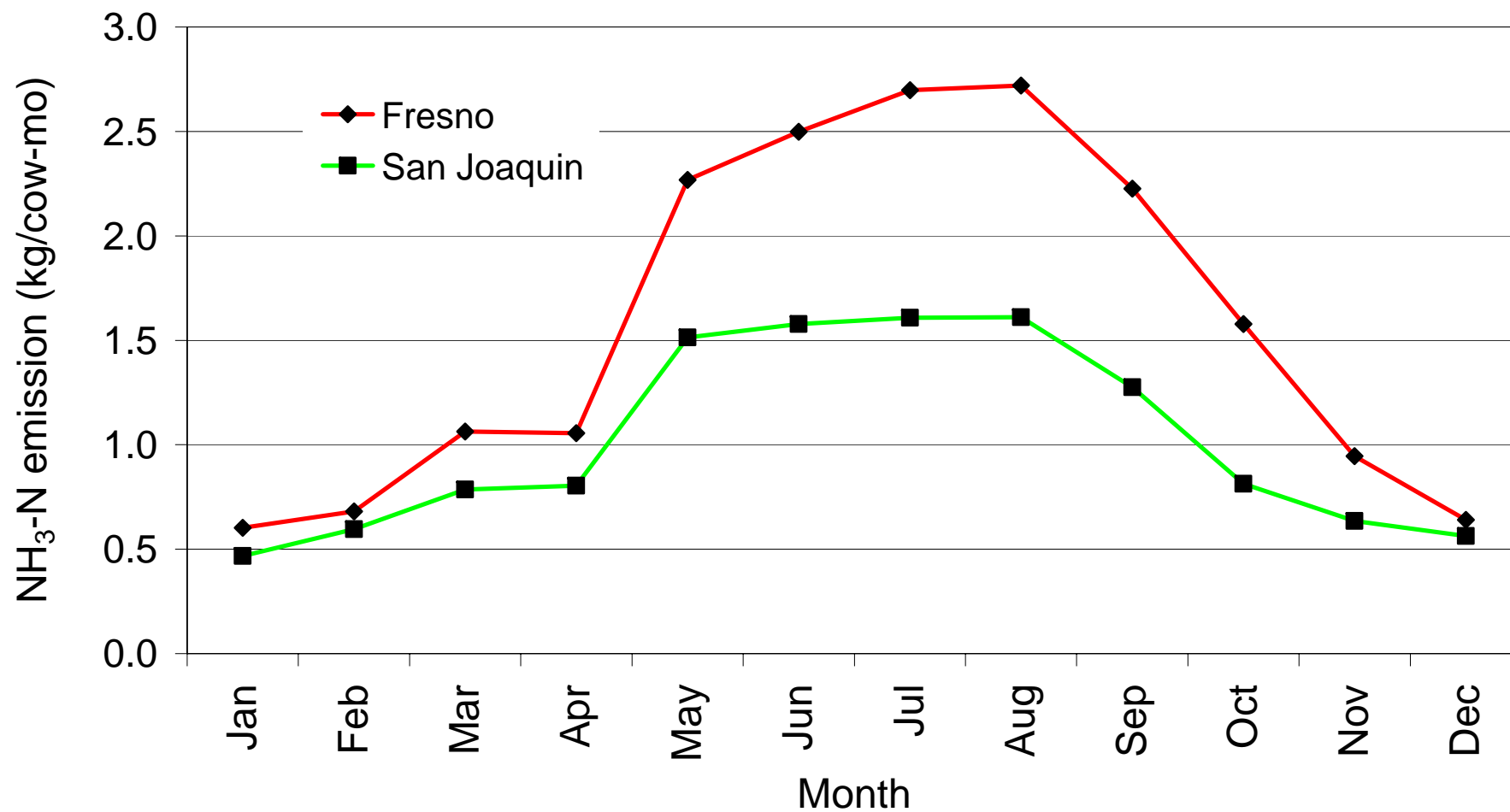Predicted NH$_3$ Emissions from Dairy Lagoons of Different Depths
(pH = 7.4, TAN = 450 mg/L, Fresno)

Predicted NH$_3$ Emissions from Dairy Lagoon at Different pH
(H=25ft, TAN=450mg/L, Fresno)

Predicted NH$_3$ Emissions from Dairy Lagoons at Different Locations

Summary

➢ Farm Emission Model is under development and will be a scientific tool for estimating gaseous emissions from dairies under different conditions and determine the critical factors that affect the emissions.